REPORT SUMMARY

Dripping mossy interior of lower montane forest near the top of Hides Ridge

BACKGROUND AND AIMS

The island of New Guinea has an exceptionally high biodiversity, and a large proportion of its fauna and flora is found nowhere else on Earth. Charismatic species such as birds-of-paradise, echidnas and tree kangaroos are widely known and often have great cultural significance for local communities in Papua New Guinea (PNG). Less well known is that the flora and smaller fauna of PNG are not only incredibly diverse but remain poorly documented, and numerous plants and animals that are new to science are being discovered every year.

Studies conducted prior to Project development documented substantial biodiversity values in the Upstream Project Area of the Papua New Guinea Liquefied Natural Gas (PNG LNG) Project. These were summarised in ExxonMobil PNG Limited's (EMPNG) Biodiversity Strategy as (i) extensive intact forest, (ii) high floristic diversity, (iii) high faunal diversity, (iv) endemic species, (v) unique assemblages of species, (vi) species of conservation concern, and (vii) biodiversity of importance to local communities for resource use and cultural and spiritual purposes.

As part of its commitment to safeguarding these biodiversity values in the Upstream Project Area EMPNG's Biodiversity Strategy outlines how biodiversity has been, and will continue to be, assessed and managed. To evaluate the success of this long-term strategy, EMPNG has developed a series of four Programmed Monitoring Activities (PMAs). These PMAs will provide data to compare against a series of Key Performance Indicators (KPIs) that align directly with the major objectives of EMPNG's Biodiversity Strategy.

Trends in species diversity are an important KPI, and documenting any changes in diversity will contribute to ongoing evaluation of whether the Project is successfully meeting the four major objectives of the Biodiversity Strategy: *Maintain the intactness of the Upstream area as a whole; Conserve the priority ecosystems; Protect focal habitats;* and *Identify, measure and offset significant residual imapcts* (EMPNG PNG LNG Biodiversity Strategy; available online).

To provide high-quality information on trends in species diversity in the Upstream area of the PNG LNG Project, the Programmed Monitoring Activity PMA3 was developed. The specific objectives of PMA3 are to conduct biodiversity surveys in order to collect quantitative, repeatable data on the diversity of species in Biodiversity Assessment Areas (BAAs) established in and around the areas affected by the PNG LNG Project, and in protected areas established or enhanced as part of EMPNG's biodiversity offset program. Diversity is expressed as the number of species, the composition of species assemblages, and the abundance of target species, as compared with a defined baseline.

The first PMA3 biodiversity surveys were conducted during 2015 in two BAAs, one established at Hides Ridge (BAA 1) and the other on the Agogo Range near Moro (BAA 2). This report presents the results of these surveys; it provides baseline data on biodiversity in the two BAAs against which future monitoring surveys can be compared, assesses the current biodiversity values of the survey areas and the potential impacts of linear infrastructure corridors on these values, and supports EMPNG's goal to safeguard biodiversity values in the Upstream Project Area.

Survey dates

10th June–8th July 2015

Brief description of the survey area

Detailed descriptions of environments in the Upstream Project Area are presented in the Project EIS, and the region's biodiversity values are summarised further in the EMPNG Biodiversity Strategy. Extensive forest cover remains throughout the Upstream Project Area and there are marked variations in vegetation composition and structure in accordance with elevational gradients and substrate type (Figures 9–13). Long-term rainfall data are not available for either BAA but the Upstream Project Area lies within the high-rainfall belt that extends across the southern slopes of PNG's central cordillera and annual rainfall totals in excess of 4,000 mm with limited seasonality are typical. The rainfall regime in this area is classified as 'Continuously heavy' (McAlpine et al. 1983).

The locations of both BAAs are shown in Figure 1 and brief descriptions of the environments encountered in each BAA are presented below.

BAA 1: 10–25 June 2015.

BAA 1 was established on Hides Ridge in Hela Province. It covers elevations between 2,100 and 2,750 m above sea level (asl), and was divided into two elevational bands, with three survey transects located at 2,100–2,400 m asl in the area between Wellpad C and Wellpad D, and three transects at 2,660–2,780 m asl located between Wellpads E and G (Figures 2–4).

The entire length of Hides Ridge, spanning both elevational bands, is covered with lower montane rainforest dominated by *Trisyngyne* (formerly *Nothofagus*). It includes the FIMS vegetation types LN/LsN 'small crowned and very small crowned lower montane forest with *Nothofagus*' (Figures 9–10). At these elevations the forests are cool, moist and mossy, and epiphytes, particularly ferns, orchids and rhododendrons are abundant.

BAA 2: 27 June–8 July 2015.

BAA 2 is located on the Agogo Range near Moro in Southern Highlands Province (Figure 1). Two survey transects were established at elevations of 1,000–1,080 m asl in the area west of Arakubi Quarry and east of the pipeline right of way (ROW), and three survey transects at elevations of 1,340–1,410 m asl in the vicinity of KP107 (Figures 5–7).

The forests in BAA 2 tend to have a wider variety of dominant tree species, and epiphytes are rare or absent. At KP107 the forest is FIMS vegetation type LsN 'very small crowned lower montane forest with *Nothofagus*'. The forest is more varied in composition than in BAA 1 and includes mixed *Trisyngyne* forest and *Papuacedrus papuana-Elaeocarpus-Cryptocarya* forest (Figure 11). Two FIMS vegetation types are present at Arakubi Quarry. The first is HsN/Hm 'Small crowned hill forest with *Nothofagus*/Medium crowned hill forest' which is restricted to an area of secondary forest below 1,000 m asl on the eastern side of Arakubi (Figure 12). Further to the west, adjacent to the ROW, the forest cover is primary and mapped as FIMS vegetation type LsN/L 'Very small crowned lower montane forest with *Nothofagus*/Small crowned lower montane forest' (Figure 13). In this area lower montane forest dominated by *Trisyngyne* is generally restricted to the ridges and upper slopes.

Survey approach

Surveys for frogs, non-volant mammals (rodents, small marsupials), bats, and mist-netting activities for birds were conducted on six permanent transects established in BAA 1 along the Hides Ridge access road and Pipeline ROW (Figure 2), and on the five permanent transects in BAA 2 established along the pipeline ROW at KP107 (Figures 6, 8) and adjacent to the Arakubi Quarry (Figure 5). Each of these 11 transects extended for 220–250 m into the forest and were perpendicular to the ROW or forest edge. Coordinates for all transects are presented in Appendix 1. In addition, plant plot and camera trapping surveys were undertaken in the same elevational bands in each of BAA 1 and BAA 2 but the activities were carried out at some distance from the transects. In the case of plant plots this was to limit disturbance to transect habitats. For camera trapping, the arrays were positioned away from transects to avoid regular disturbance of camera trapped areas. Locations of plant plots and camera trap arrays are illustrated in Figures 3–4 (BAA 1) and 5–7 (BAA 2) and their locations are provided in Chapters 1 and 4 respectively.

The permanent transect method was designed to detect potential impacts of Project activities at various spatial scales and over various time frames. Perpendicular alignment of transects with respect to linear infrastructure (a road, Pipeline ROW or quarry edge) samples a gradient of potential disturbance—heaviest at the forest edge and progressively less so with increasing distance into the forest. Physical changes at the edge ('edge effects') include greater light and wind penetration, potential dust and noise pollution, and edges are also susceptible to invasion by exotic weeds and pests. For most groups of organisms 'edge effects' are likely to attenuate rapidly and the 220–250 m transects should extend beyond any major impacts.

It should be noted that construction of the Hides Wellpad access road began in 2011 and of the Hides spineline ROW in mid-2013; reinstatement was completed in the first quarter of 2014. Reinstatement of the ROW at KP107 was signed off a year earlier in February 2013 but the access road to KP107, and Arakubi Quarry, have been established for many years. Therefore, the plants and animals in forest adjacent to these linear infrastructure corridors have been exposed to edge effects for at least 1–2 years before the 2015 survey.

Patterns in species distributions along the transects should be evident from the 2015 survey results for at least some groups of plants and animals, and these should inform on their variable sensitivity to 'edge effect' impacts. In coming years, as data are collected at the same sites and using the same methods, it will also be possible to determine whether any broader changes are occurring, potentially affecting even the more sheltered areas of forest.

MAJOR RESULTS

At least 579 animal and plant species were documented during the surveys. This includes at least 35 species that were previously unknown to science (new species) or that were known but have yet to be scientifically named (undescribed), and14 species listed in a category higher than Least Concern by the IUCN. In the following text new and undescribed species are indicated by the term "sp." followed by a unique identifier (e.g. *Genus* sp. 1). A summary of the major results is presented below and total numbers of species documented are presented in Table 1.

Taxon accounts

Vegetation

A total of 318 plant species was recorded from 12 standardised survey plots, including 234 at BAA 1 and 140 at BAA 2. Only 56 species (17.6%) are shared between the two areas, confirming that they support quite different plant communities. Six undescribed plant species were collected, all but one of these completely new to science. Two plant species listed as 'Near Threatened' and one as 'Endangered' by the IUCN were also recorded. Three plants were recorded from the island of New Guinea for the first time, and three others represent significant new populations of poorly known species. Examination of vegetation structure and community composition in plots at different distances from the ROW found little evidence for an impact of the ROW on adjacent plant communities. However two groups, epiphytes and bryophytes, were significantly more diverse and abundant respectively closer to the forest edge than further into the forest; both of these groups contain species that thrive in the drier, lighter conditions typical of forest edge habitats. The survey identified two plant families, the filmy ferns (Hymenophyllaceae) and nettles (Urticaceae) as particularly useful subjects for monitoring during the PMA3 program.

Frogs

A total of 37 frog species was documented during this survey using two quantitative and replicable field methodologies: Visual and Audio Encounter Surveys (VAES) and acoustics recorders. Species diversity and composition differed significantly between the two BAAs, with 10 frog species found on Hides Ridge in BAA 1, 29 species on the Agogo Range near Moro in BAA 2, and only two species (5.4%) shared between them.

More than half of the frog species encountered are undescribed (n= 23; 62%) but many of these were previously known to occur in the Upstream Project Area. One of the newly discovered species is currently known only from BAA 2 and genetic analysis suggests that it represents an entirely new genus. Two of the recorded frog species, *Choerophryne burtoni* and *Oreophryne notata*, are classified as Data Deficient by the IUCN due to the lack of information on their extent of occurrence, status and ecological requirements; both are relatively abundant in the survey sites.

Analyses of data from the VAES searches and bioacoustic recorders found no evidence for shifts in species diversity or composition with increasing distance from the ROW in either BAA. To date, establishment of the ROW clearings in BAA 1 on the Hides spine-line and in BAA 2 on the Agogo Range near Moro thus had no detectable impacts on local frog populations. Analyses of the relative abundance of each species highlighted some potential 'Indicator Species' that might be useful for detecting future changes in species abundance.

Future monitoring surveys will improve the robustness of the current analysis of 'edge effects' and also provide for analyses of changes in frog diversity and community composition over time. However, on current evidence the biodiversity values of frog assemblages in both BAAs appear to remain intact.

Birds

A total of 175 bird species was recorded during the 2015 surveys (Hides Ridge—81 species; Agogo Range—110 species), including nine species not previously reported for any site surveyed within the Kikori Basin or adjacent areas. The limestone forests along Hides Ridge and on the Agogo Range near Moro support numerous rare, conservation-listed, hunting-sensitive and restricted range species. Seventeen conservation listed bird species were recorded, including three species listed by the IUCN as Vulnerable (Papuan Eagle *Harpyopsis novaeguineae,* Pesquet's Parrot *Psittrichas fulgidus,* Black Sicklebill *Epimachus fastosus*) and one as Near Threatened (Ribbon-tailed Astrapia *Astrapia mayeri*). All conservation-listed species documented during the 2015 surveys are also Protected under PNG law.

Of the various methods trialled in 2015, mist netting proved to be an unviable method for repeated, standardised monitoring of birds in both BAAs due to logistic constraints and the rugged karst terrain. By contrast, trials of the use of camera traps proved successful in detecting normally wary birds and mammals (see below). In addition, a trial of automated sound recordings demonstrated that three iconic birds-of-paradise resident on Hides Ridge (King of Saxony Bird-of-paradise *Pteridophora albertisi*, Black Sicklebill *Epimachus fastosus*, Brown Sicklebill *E. mayeri*) were all significantly less likely to vocalise at positions next to the ROW than in forest 170 m from linear clearings. The causes of this apparent partial avoidance of the forest edges are presently unknown.

Camera traps

A pilot study was conducted to test the effectiveness of camera traps for monitoring wildlife populations in both BAAs. The method proved highly successful. Forty-nine species (21 mammals, 28 birds) were photographed in 366 camera trap events, with most species photographed on multiple occasions. Species of conservation significance recorded on camera traps include Western Montane Tree Kangaroo (*Dendrolagus notatus*; IUCN Endangered), Papuan Eagle (*Harpyopsis novaeguineae*; IUCN Vulnerable), Small Forest Wallaby *Dorcopsulus* cf. *vanheurni* (IUCN Near Threatened), New Guinea Quoll (*Dasyurus albopunctatus*; IUCN Near Threatened), Woolley's Three-striped Dasyure (*Myoictis leucura*; IUCN Data Deficient) and Greater Melampitta (*Melampitta gigantea*; restricted-range). An additional three mammal species and three bird species were recorded for the first time in the Kikori Basin during the pilot study. The results clearly demonstrate the utility of camera trapping for species inventory as well as quantitatively documenting some of the regions rarest and most elusive mammals and birds. With an expanded sampling protocol, camera trapping is expected to provide quantitative datasets that will inform on some of the region's most sensitive animal species.

Non-volant (non-flying) mammals

A total of 11 species of rodents and two species of marsupials was trapped during the survey. Three other species were recorded by other means, one from a capture in a mist net and a daytime sighting, one from a road casualty, and one from bones and teeth contained in dog scats. Only one species was recorded in both BAAs—the IUCN Near Threatened New Guinea Quoll (*Dasyurus albopunctatus*). Camera traps provided records of one monotreme (Short-beaked Echidna, *Tachyglossus aculeatus*), six additional species of marsupials including the IUCN Endangered Western Montane Tree Kangaroo, *Dendrolagus notatus*, and four additional species of rodents. One introduced rodent species (Pacific Rat, *Rattus exulans*) was trapped in BAA 2, while a second (Black Rat, *Rattus rattus*) was recorded at the Hides Gas Conditioning Plant.

One of the native rodent species (*Rattus* sp. 'spiny') recorded at BAA 2 is definitely undescribed although it has been detected on two other recent surveys in Hela and Western Provinces. Several other rodent species within each of the genera *Rattus* and *Paramelomys* are morphologically cryptic (i.e. very similar in appearance) and were distinguished from each other using genetic methods. Although these species are also difficult to assign with confidence to named forms, for all but two of the species, genetic analyses demonstrated connections with other regional populations. The two exceptions—*Paramelomys*, *P.* cf. *mollis* C and *P.* cf. *rubex* B—are currently known only from BAA 1 and BAA 2, respectively.

Statistical analysis of the mammal trapping results indicate that species of *Paramelomys* are less common within 100-150 m of the ROWs in both BAAs, whereas the abundance of native *Rattus* species appears to be unaffected by the ROW. The trapping results from transects at the lower elevation in BAA 1 from 2015 were compared with a collection of recently accumulated bones recovered from a nearby cave during pre-construction surveys. While this comparison revealed several differences in composition, it is unclear whether these are due to sampling biases or reflect genuine ecological changes, and if the latter, whether any changes are due to project impacts.

Bats

Acoustic recordings of echolocation calls as well as trapping methods were used to document the diversity of bat communities on all transects in BAA 1 and BAA 2. A total of 66 full nights of acoustic recordings was obtained using bat detectors which were placed at increasing distances (50 metre intervals) starting at the forest edge. A total of 19 bat species was recognised based on their signature echolocation call types. One unique call type recorded at Arakubi Quarry differs from that of all known bats and probably represents a species new to science. Capturing a representative of this species to obtain morphological and genetic information is a high priority for future surveys. The identification of several other bat species also needs to be confirmed from captures followed by genetic and acoustic analysis work.

Bat diversity as calculated by various measures including Species Richness and Phylogenetic Diversity was significantly greater at lower elevations, especially at ~1000 m asl adjacent to Arakubi Quarry in BAA 2 where it is likely that rocky outcrops provide important habitat for cave-roosting species. However, there was no statistically significant contrasts in bat diversity or species composition of bat communities at increasing distances from the forest edge. The 2015 survey results do not identify any negative impacts on the bat communities associated with the ROW linear infrastructure.

By contrast, some species appear to be more abundant along the edges than inside the forest and these may have benefited from the creation of new habitat types. The analyses highlighted some potential Indicator Species that might be useful for detecting subtle changes in community composition that might be related to Project influences.

Table 1. Number of species documented during the 2015 PMA3 Surveys, number estimated to be new to science and/or undescribed, and the number of species holding an IUCN threat classification above Least Concern.

	Plants	Frogs	Birds	Non-volant Mammals*	Bats	TOTALS
Total Species	318	37	175	28	21	**579**
New Species	6	23	0	5+	1+	**35+**
IUCN Species	3	2	5	4	0	**14+**
*Not including bones in an owl roost which added 21 species						

Significant habitats

Both of the BAAs clearly retain high biodiversity values, with forest that remains largely intact and supports a large number of new and conservation-significant plants, frogs, birds and mammals including tree kangaroos and birds-of-paradise. Both BAAs represent special areas for birds as they support numerous rare, conservation listed, hunting-sensitive and restricted range species. The high elevation and rugged karst terrain of Hides Ridge have long protected its resident bird community from hunting and agricultural practices that threaten montane faunal communities in many other parts of PNG. The rugged limestone forests around KP107 support similar biodiversity values, though with a different species complement, notably including one of few known populations of the restricted range Greater Melampitta *Melampitta gigantea*.

Mammal diversity is also high in both BAAs, which support populations of conservation-listed mammals as well as new and undescribed species. Among the non-volant mammals, special note should be made of the high abundance in both BAAs (but especially so in BAA 2) of an undescribed Small Forest Wallaby that is related to the IUCN Near Threatened *Dorcopsulus vanheurni*. Elsewhere this undescribed species has declined dramatically and the Upstream Project Area could be an important future stronghold for this species. Among the bats, diversity was particularly high at the Arakubi transects and this may be due to the nearby occurrence of cave-bearing limestone outcrops. Populations of cave-roosting bats rely on the survival of and access to both roost and foraging habitats, and the Upstream Project Area, with its extensive areas of limestone karst, poses an excellent context for conservation of many bat species. Effective management of the complex landscapes occupied by bats is challenging but important because bats are widely acknowledged to be a keystone group in tropical forest ecology.

Of significance for the long-term maintenance of biodiversity values in the Upstream Project Area is that there was minimal overlap in the fauna and flora encountered in the two BAAs. This is probably due in large part to the different altitudes accessed at these sites, and suggests that establishment of at least one more additional BAA at lower altitudes in the Upstream Project Area may be warranted.

Threats

Apart from the direct impacts of establishing linear infrastructure in forest habitats, including physical disturbance during construction and ongoing risks of mortality to dispersing animals, two additional processes associated with construction of the pipeline ROW in the Upstream Project Area have the potential to effect biodiversity values there in the long term. These are 1) decreasing habitat quality adjacent to the ROW due to edge effects (e.g. Andrews et al. 2015) and 2) improved access to the forest by humans (for hunting and gardening) and by invasive species, both native and exotic.

The 2015 survey found some evidence for 'edge effects' in several of the plant and animal groups studied, including rodents, bats (including some that seem to have benefitted) and birds (three bird-of-paradise species that were less likely to be heard calling next to the ROW than in forest away from these linear clearings). However, in each case the effects seem to be confined to habitats close to the forest edge; this includes the spread of invasive weeds and pests that were only detected along the immediate forest edges.

Longer-term data, collected from the same sites over multiple surveys, are required to determine whether these impacts are stable or changing (potentially increasing or decreasing) and to determine whether there are changes affecting biodiversity values on a broader scale within the Upstream Project Area.

The team identified a number of potentially broad-ranging threats to components of local biodiversity. The construction of the linear ROW infrastructure and associated roads has improved accessibility into formerly remote areas of forest and this may have led to an increase in direct hunting pressure by both local people and by feral dogs. Predation by wild dogs on the IUCN Near Threatened Small Forest Wallaby was documented at the high elevation transects in BAA 1 and it is likely that they also prey on other conservation-listed species of mammals and birds. The impacts of increased predation on large herbivores in particular might have broader ecological consequences that might be felt at considerable distances from the ROW.

Exotic rodent species were detected only at KP107 in BAA 2 where they were confined to the forest edge, and at Hides Gas Conditioning Plant. While the risk of short-term expansion of these species beyond the most disturbed contexts may be quite low, their presence in the BAAs carries with it an additional risk of the transfer of novel pathogens into the native wildlife. This can happen through interspecific contact including predation (e.g. quoll eating exotic rat) and attempted interbreeding (e.g. native and exotic *Rattus* spp.) or through environmental contamination (water, soil etc). The spread of new pathogens into naive wildlife populations is acknowledged globally as a threat to biodiversity.

Overall conclusions

1. The results of the 2015 PMA3 survey indicate that both BAAs retain high biodiversity values for all surveyed taxa.

2. The plant and animal communities found in each of the BAAs are quite distinct, with only a small proportion of species in common. This is consistent with the contrasting elevations of the two BAAs.

3. Both BAAs produced records of numerous undescribed species of plants, frogs, marsupials, rodents and bats. Entirely new species of plants and frogs were discovered, and a potentially new and unknown species of bat was recorded acoustically.

4. Both BAAs continue to support many rare, conservation listed, restricted range and hunting-sensitive species. Hides Ridge in particular supports populations of iconic species of tree kangaroos and birds-of-paradise. The lower elevations of BAA 2 also support high diversities of frogs and mammals including a number of species with known ranges restricted to the Upstream Project Area.

5. Several conservation significant species, and species not previously recorded from the Kikori basin, were detected using camera traps. These results clearly demonstrate the utility of camera trapping in documenting the true diversity of rare and elusive vertebrate fauna within sampling areas. Moreover, given the brevity of this pilot study, it is predicted that statistically useful datasets will be collected for a variety of priority monitoring taxa under an expanded sampling protocol.

6. Analysis of acoustic data on Hides Ridge revealed that three birds-of-paradise were significantly less likely to vocalise next to linear infrastructure clearings than in forest 170 m away. The reasons for this apparent partial avoidance of Project infrastructure are still unclear.

7. Several undescribed rodent species were detected by genetic analysis and this method also demonstrated connections with other regional populations for all but two of the mammal species.

8. Statistical analysis of data from the permanent transects found small but significant differences in diversity or community composition at different distances from the ROW, with some significant contrasts in rodents. In all cases, these changes appear to be confined to a relatively narrow zone within 50–100 m of the ROW clearing. For frogs and bats, some contrasts were noted but with insufficient data to establish statistical significance.

9. The fact that subtle influences were detected from a single year of survey data demonstrates the potential future power of the transect method to detect any changes across all groups of plants and animals. The transect data from 2015 also represent a baseline for future monitoring of broader-scale changes in species diversity and community composition.

10. Overall, the preliminary results indicate that the biodiversity values of the Upstream Project Area remain intact, with only minor impacts detected in close proximity to the Project infrastructure. Significant changes, including criteria exceedance requiring a response, were not detected for any taxa. However, some potential threats warranting further investigation were identified and a more robust assessment will be possible following completion of the 2017 PMA3 survey.

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McAlpine, J. R., Keig, G. & Falls, R. 1983. *Climate of Papua New Guinea*. Canberra: CSIRO.

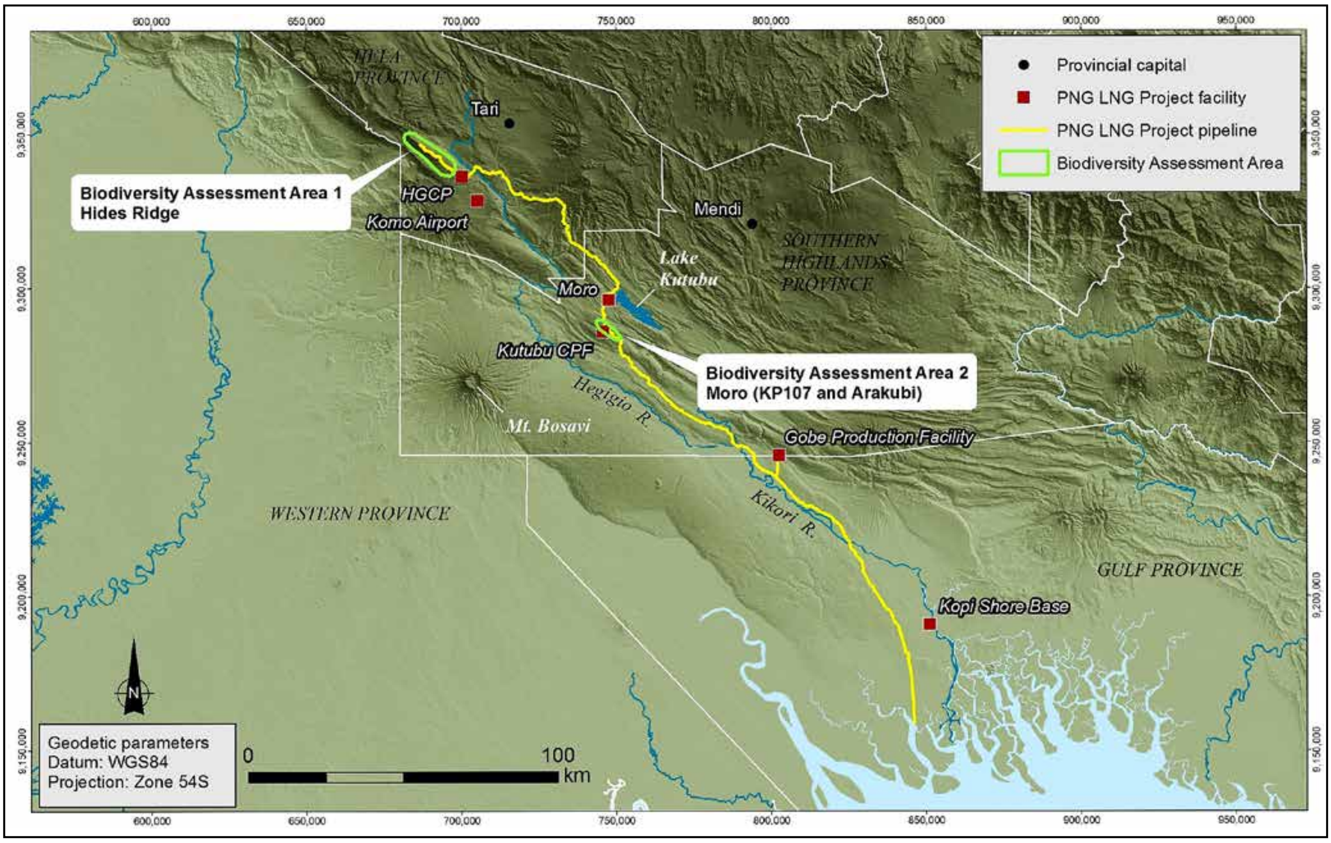

Figure 1. Regional map showing location of the two BAAs surveyed during the PMA3 2015 survey.

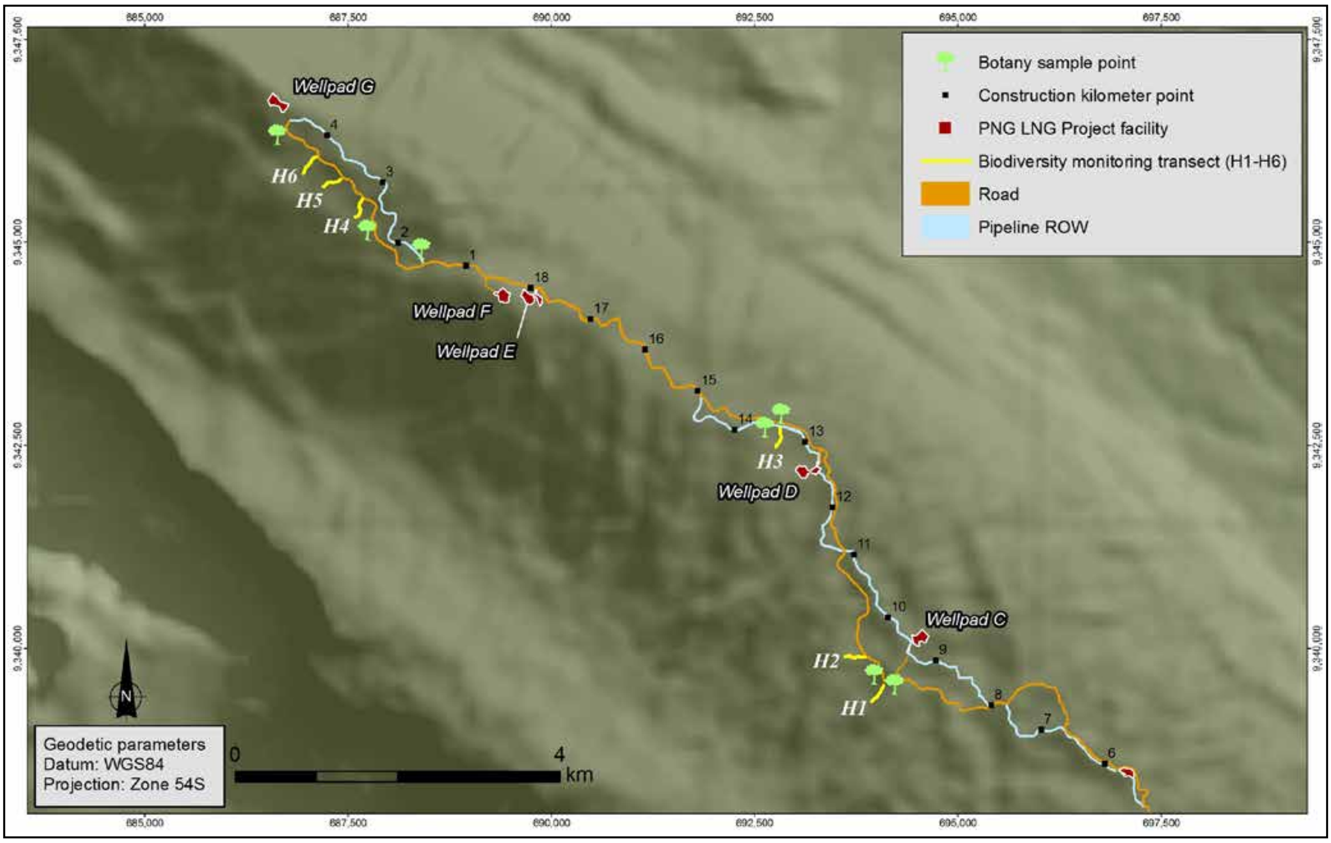

Figure 2. Map showing locations of the six major transects and seven plant plots in BAA 1.

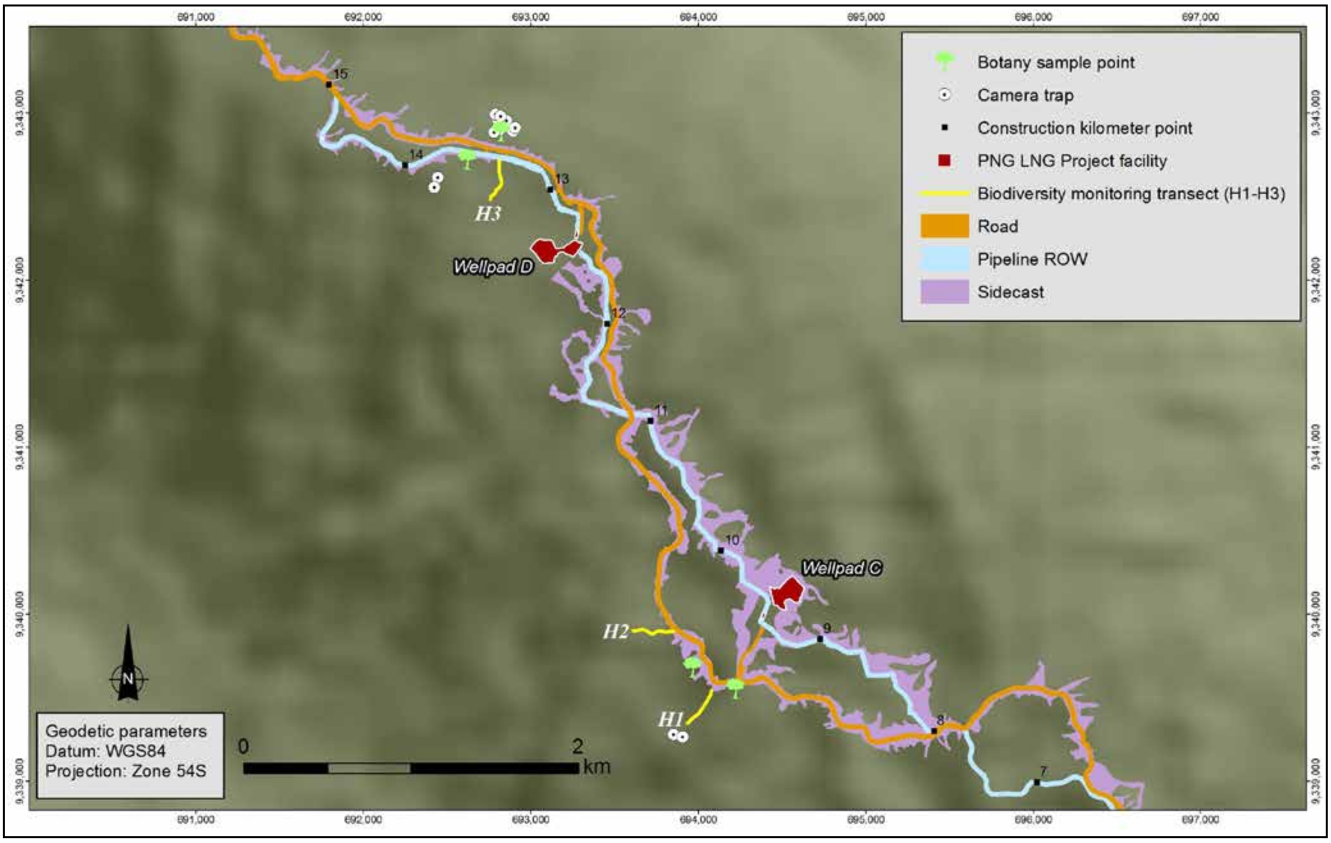

Figure 3. Map of lower elevations in BAA 1 showing details of Transects 1–3, plant plots and camera trap arrays.

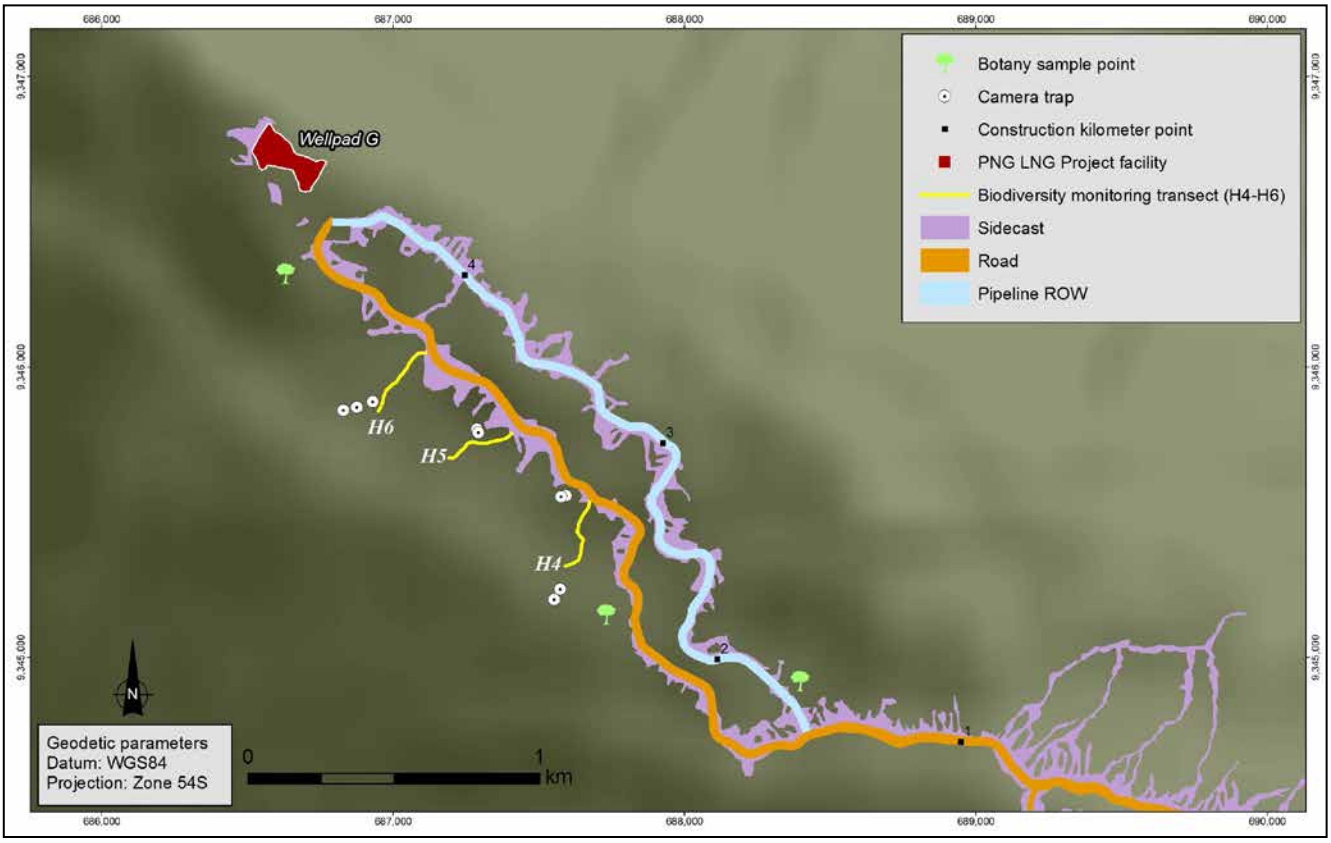

Figure 4. Map of upper elevations in BAA 1 showing details of Transects 4–6, plant plots and camera trap arrays.

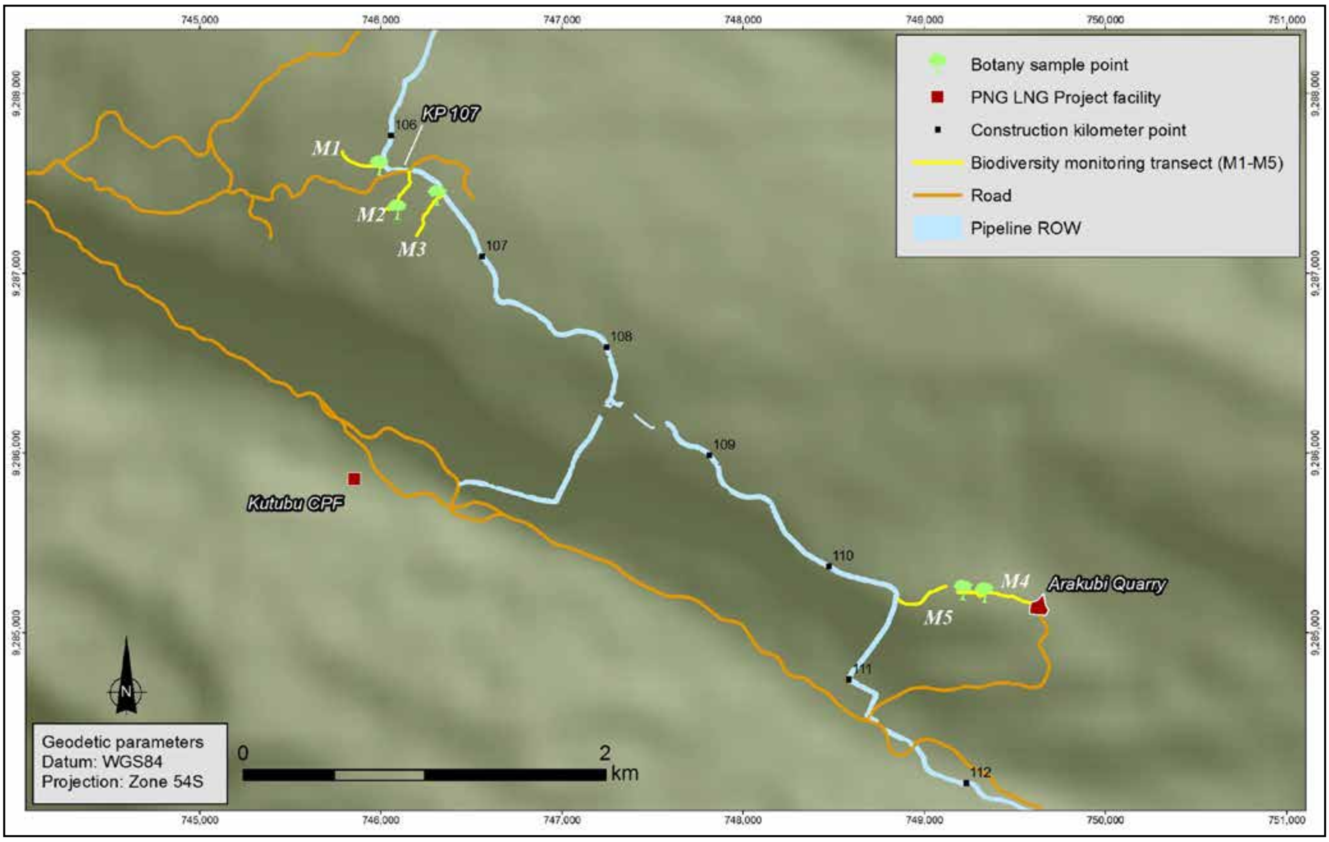

Figure 5. Map showing locations of the five major transects and five plant plots in BAA 2.

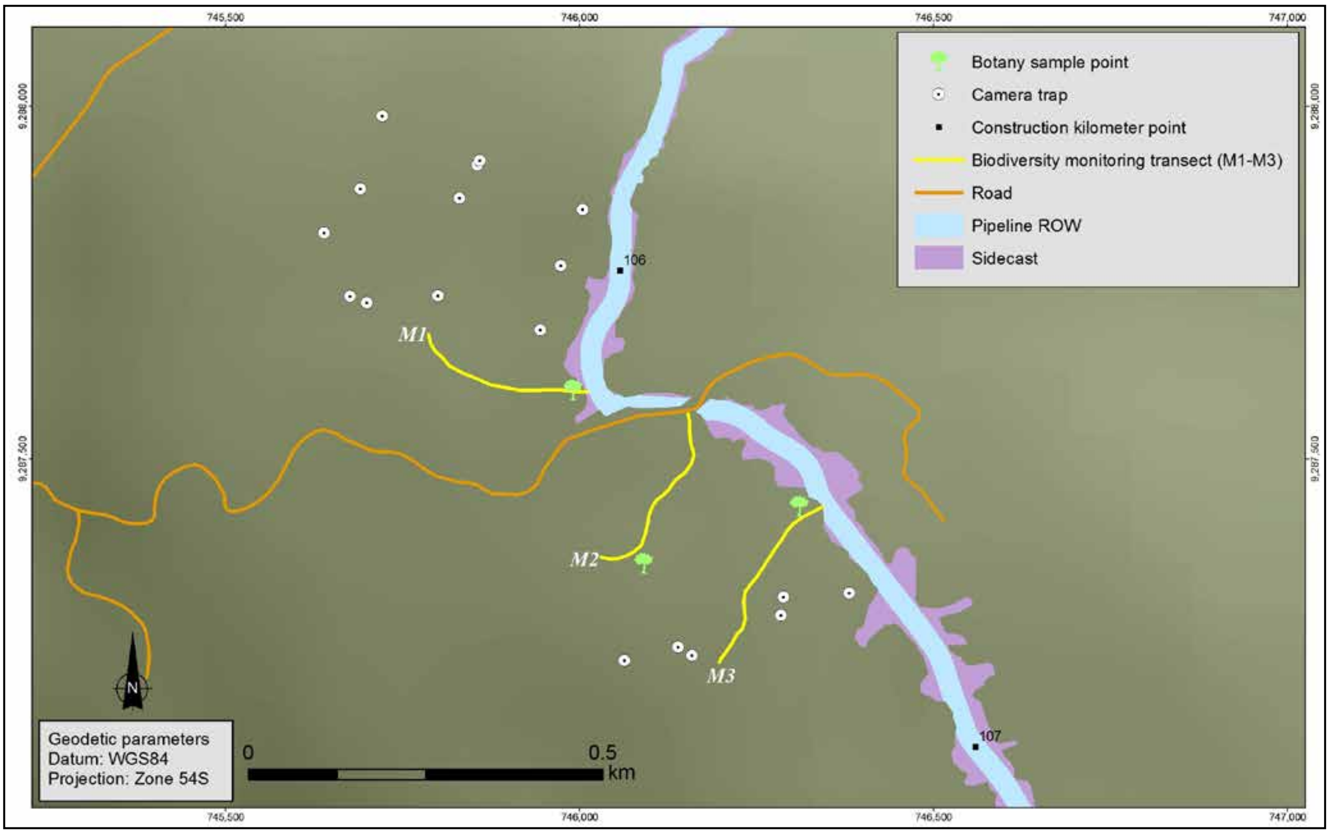

Figure 6. Map showing locations of the three major transects, plant plots and camera trap arrays at KP107 in BAA 2.

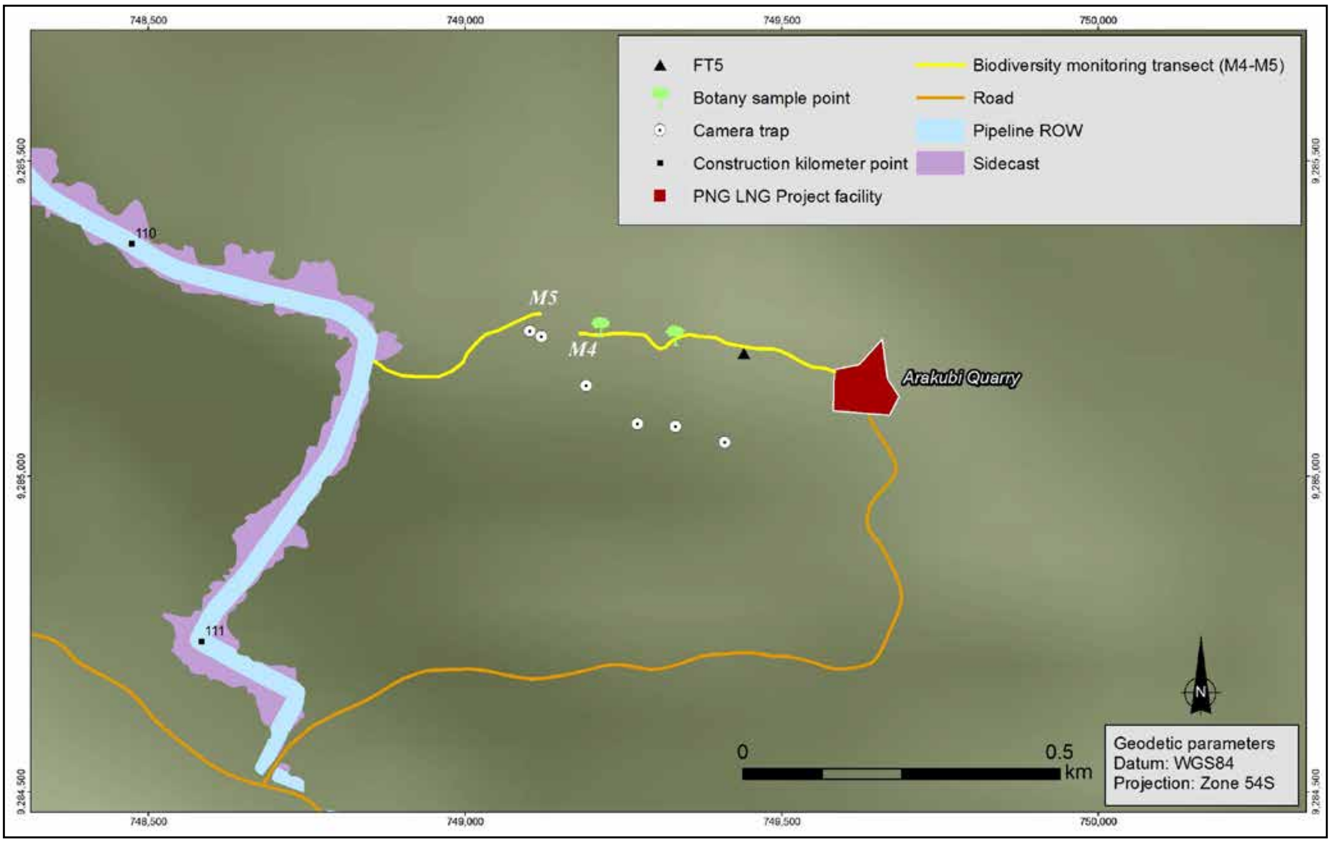

Figure 7. Map showing locations of the two major transects, plant plots and camera trap arrays at Arakubi Quarry in BAA 2.

Figure 8. Linear infrastructure at KP107 in BAA 2. Note the sharp boundary between the ROW clearing and adjacent forest on the left.

Figure 9. Lower montane forest on Hides Ridge in BAA 1

Figure 10. Interior of lower montane forest at the highest elevations on Hides Ridge in BAA 1.

Figure 11. Transect marked with blue tape through lower montane forest at KP107 in BAA 2. Note the minimal disturbance to vegetation when establishing transects. A small temporary shelter from the rain constructed off the transect can be seen in the background.

Figure 12. Secondary hill forest on transect M4 at Arakubi Quarry in BAA 2.

Figure 13. Lower montane forest near transect M5 at Arakubi Quarry

Figure 14. Most of the 2015 PMA3 survey team, from left to right: Dopo Uriye, Kyle Armstrong, Muse Opiang, Amos Ona, Stephen Richards, Fanie Venter, Iain Woxvold, Ken Aplin and Leo Legra

APPENDICES

Appendix 1. Coordinates and elevations (at start) for each of the 11 standard survey transects established in BAA 1 and BAA 2.

BAA	Transect	Position	Coordinates	Elevation
1	H1	Start	S5.97229° E142.75333°	2140
1	H1	End	S5.97416° E142.75198°	
1	H2	Start	S5.96915° E142.75127°	2150
1	H2	End	S5.96913° E142.74908°	
1	H3	Start	S5.94369° E142.74177°	2285
1	H3	End	S5.94579° E142.74132°	
1	H4	Start	S5.91835° E142.69531°	2685
1	H4	End	S5.92036° E142.69456°	
1	H5	Start	S5.91621° E142.69289°	2745
1	H5	End	S5.91699° E142.69095°	
1	H6	Start	S5.91372° E142.69021°	2730
1	H6	End	S5.91553° E142.68877°	
2	M1	Start	S6.44023° E143.22424°	1390
2	M1	End	S6.43950° E143.22221°	
2	M2	Start	S6.44051° E143.22552°	1380
2	M2	End	S6.44236° E143.22442°	
2	M3	Start	S6.44169° E143.22724°	1365
2	M3	End	S6.44368° E143.22594°	
2	M4	Start	S6.46206° E143.25662°	995
2	M4	End	S6.46152° E143.25299°	
2	M5	Start	S6.46124° E143.25242°	1050
2	M5	End	S6.46192° E143.25004°	

Appendix 2. IUCN Red list categories used in this report

The conservation status of each species encountered was determined using the internationally recognized IUCN Red List of Threatened Species and the PNG Fauna (Protection and Control) Act 1966.

The Red List provides taxonomic, conservation status and distribution information on plants and animals. The IUCN Red List criteria identify three categories of threatened species which are considered to be facing a heightened risk of extinction: Critically Endangered (CR), Endangered (EN) and Vulnerable (VU). Five additional categories are Extinct, Extinct in the Wild, Near Threatened (NT), Least Concern (LC) and, for those species for which data are insufficient to reach a conclusion, Data Deficient (DD). Species that have not been assessed by the IUCN are listed as Not Evaluated (NE).

In this report the term 'conservation listed' is applied to all species listed by the IUCN as threatened, Near Threatened or Data Deficient and to those species listed as Protected under PNG law.